PLANT REQUIREMENTS FOR MANUFACTURE OF SALICYLIC ACID

TECHNICAL AIDS BRANCH
INTERNATIONAL COOPERATION ADMINISTRATION
Washington, D. C.

FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

The original report was prepared by Penniman and Browne, Inc., Baltimore 2, Maryland.

Technical information, as well as review, was provided by R. Poliakoff, Industrial Consultant, 126 Eleventh Avenue, New York 11, New York.

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For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

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S A L I C Y L I C A C I D

INTRODUCTION

The purpose of this report is to present basic information for establishing and operating a chemical plant in a foreign country for the production of salicylic acid.

In the United States salicylic acid is manufactured in three quality grades: technical, crystalized and sublimed (USP). The technical grade contains 98-99% real salicylic acid and sells for about $0.39 a pound. Crystalized and U.S.P. grade sell for about $0.48 and $0.55 per pound respectively. All three of these grades can be manufactured in this plant.

Since the technical grade acid has the largest use, all facts and figures shown in this report will be based on the production of technical grade acid.

GENERAL ASSUMPTIONS

In order to make realistic estimates in this report, certain assumptions are made. These are:

1. The costs of the building and general facilities are based on United States prices.

2. Material costs are based on sizes and specifications of materials used in the United States.

3. Labor costs are based on the average for the industry as recently published by the United States Bureau of Labor Statistics.

4. Adequate power and water are available at the plant site.

5. Adequate transportation facilities are available at the plant site.

6. The plant operates twenty-four hours a day, two hundred and fifty days a year.

7. No special provision is made for the training of new personnel. It is assumed that learner's rates are paid in such cases.

8. The following items cannot be estimated realistically:

   A. Land value.
   B. Distribution and selling costs.
   C. In-freight and out-freight.
   D. Administrative costs.
   E. Taxes.

   While general estimates will be made of each of these items, for the purpose of completing cost estimates, adjustment should be made in accordance with actual local costs.

   In fact, all cost estimates contained in this report should be adjusted to conform to local conditions.

9. Columns are provided in the tables included in this report to facilitate the conversion of cost figures to conform with local costs.

PRODUCT SPECIFICATIONS

Technical grade salicylic acid is made from purchased phenol, sodium hydroxide, carbon dioxide, and sulfuric acid.

PRODUCTION CAPACITY

The production capacity of this plant is 500 tons of technical grade salicylic acid based on a three shift operation of twenty-four hours a day, two hundred and fifty days per year. All cost figures are based on operating the plant three shifts, 250 days. If the potential sales warrant, the plant could be operated 330 days per year. Usually, the plant is closed for 30 days each year for repairs.

MANUFACTURING UNIT

The manufacturing unit for this plant is one ton.

MANUFACTURING OPERATIONS

OUTLINE OF PROCESS

(a) Chemical Reactions Involved:

$$C_6H_5OH + NaOH \rightarrow C_6H_5ONa + H_2O$$

$$C_6H_5ONa + CO_2 \rightarrow C_6H_4(OH)(COONa)$$

$$C_6H_4(OH)(COONa) + \tfrac{1}{2}H_2SO_4 \rightarrow C_6H_4(OH)(COOH) + \tfrac{1}{2}Na_2SO_4$$

(b) Preparation of Sodium Phenate:

Technical phenol (39°C) is mixed with a slight excess of sodium hydroxide (50%) and evaporated to dryness in equipment provided with a kneading or shearing type of agitation. After the transition from liquid to solid state occurs, the product is usually transferred to the autoclave (subsequently used for the carboxylation step) and heated to 130°C under vacuum to complete the dehydration. An intermediate ball-milling (or comparable pulverizing step) is sometimes employed, but this appears to be unnecessary if the proper type of agitation is furnished in the preliminary stage of the drying cycle.

(c) Carboxylation:

The dehydrated, and finely divided, sodium phenate is cooled to 100°C, and treated with an excess of carbon dioxide at about 6 atmospheres pressure (90-100 psig). When the desired amount of CO_2

has been absorbed (as measured by appropriate metering devices), the autoclave is heated to 140-170°C, and held at that temperature for several hours to complete the formation of sodium salicylate. The autoclave is, of course, equipped with a plew-type agitator, and also with appropriate pressure-relieving devices to insure safety of operation.

(d) Purification of Sodium Salicylate:

When carboxylation is judged to be complete, the autoclave is cooled to 100°C, and the contents are dissolved in an equal volume of water. The resulting solution is decolorized by a filtration in the presence of a mixture of activated carbon and zinc dust, and is then ready for direct conversion into technical salicylic acid.

If an exceptionally high degree of purity is desired in the salicylic acid (and if it is considered impractacal to obtain such by subsequent crystallization or sublimation of the acid), the clarified solution may be cooled to 20°C to effect crystallization of sodium salicylate hexahydrate. This product is separated from the mother liquor by centrifuging, and is re-dissolved in water to give a solution from which a purified grade of salicylic acid may be precipitated, or USP sodium salicylate may be obtained by re-crystallization.

Mother liquor and washings are used as make-up water for subsequent batches of crude sodium salicylate from the autoclave.

(e) Preparation of Salicylic Acid:

The clarified (or otherwise purified) solution of sodium

salicylate is acidified with sulfuric acid to precipitate salicylic acid, which is filtered on a centrifuge and dried in a rotary-type dryer. It is essential to avoid contamination with iron during these operations, and the equipment (precipitation, filtration, and drying) must be constructed from corrosion-resistant materials.

The salicylic acid obtained from the clarified solution of sodium salicylate (zinc dust-activated carbon filtration) will meet the trade requirements for the technical grade acid (98-99%). A higher degree of purity may be obtained by crystallizing the sodium salicylate prior to precipitation with sulfuric acid, or by re-crystallization of the acid itself from aqueous solution.

DIRECT MATERIALS

The annual cost of direct materials is listed below.

Item	Annual Requirements	Unit Cost	Annual Cost Estimated	Annual Cost Actual
39°C phenol	400 tons	$350 ton	$ 140,000	_____
76% Na_2O sodium hydroxide	175 tons	58 ton	10,200	_____
Carbon dioxide	250 tons	70 ton	17,500	_____
66° Be sulfuric acid	225 tons	24 ton	5,400	_____
Fiber drums	2500 drums	4 each	10,000	_____
TOTAL			$ 183,100	_____

SUPPLIES

Item	Annual Cost Estimated	Actual
Lubricants and hand tools	$ 200	_____
Maintenance and parts	3,000	_____
Chemicals	1,400	_____
Office supplies	400	_____
TOTAL	$ 5,000	_____

DIRECT LABOR

Occupation	Number Required	Hourly Rate	Annual Cost Estimated	Actual
Chief operators	3	$2.00	$ 12,000	_____
Assistant operators	3	1.75	10,500	_____
Laborers	6	1.50	18,000	_____
TOTAL	12		$ 40,500	_____

INDIRECT LABOR

Description	Number Required	Annual Cost Estimated	Actual
Manager	1	$ 10,000	_____
Chemist	1	8,000	_____
Office	2	8,000	_____
TOTAL	4	$ 26,000	_____

PRODUCTION TOOLS AND EQUIPMENT

Item	Size	Cost Estimated	Actual
Steel tank for phenol storage	8,000 gals.	$ 4,000	_____
Steel tank for sodium hydroxide storage	5,000 gals.	3,500	_____
Steel tank for sulfuric acid storage	4,000 gals.	3,300	_____
Agitated evaporator for sodium phenate	300 gals.	3,000	_____
Agitated autoclave for carboxylation	250 gals.	6,200	_____
Vacuum system for autoclave	---	2,500	_____
CO_2 vaporizer	2@ 500 lbs.	1,500	_____
Wood tank for sodium salicylate solution	300 gals.	300	_____
Wood plate and frame filter press	50 ft.	1,800	_____

PRODUCTION TOOLS AND EQUIPMENT (Continued)

Description	Size	Cost Estimated	Actual
Stainless steel precipitation tank	300 gals.	$ 3,800	_____
Stainless steel centrifuge tank	30 inches	6,800	_____
Stainless steel rotary dryer	20 ft.	4,600	_____
Bagging and packing equipment	----	4,000	_____
Pumps and accessories	----	4,000	_____
TOTAL		$ 49,300	_____

Installation Costs:

Item	Cost Estimated	Actual
Engineering and design	$ 29,000	_____
Installation	24,000	_____
Piping and insulation	19,200	_____
Electrical auxiliaries	6,000	_____
Yard and land improvements	6,000	_____
Contingencies	26,500	_____
TOTAL	$ 110,700	_____
TOTAL PRODUCTION TOOLS AND EQUIPMENT	$ 160,000	_____

OTHER TOOLS AND EQUIPMENT

Item	Cost Estimated	Actual
Laboratory equipment	$ 2,000	
Boiler	15,000	
Maintenance tools and materials	1,000	
TOTAL	$ 18,000	

FURNITURE AND FIXTURES

Description	Number Required	Unit Cost	Cost Estimated	Actual
Desks and chairs	3	$150	$ 450	
File cabinets	2	75	150	
Typewriter	1	200	200	
Adding machine	1	200	200	
TOTAL			$ 1,000	

PLANT LAYOUT

A flow sheet for the manufacture of technical salicylic acid is shown on page 27.

PLANT SITE

In order to provide for eventual expansion and storage a plant site of one acre will be required. The site should be located as advantageously as possible with respect to transportation facilities, power, water, fuel, sources of labor and markets.

The cost of the plant site is about $1,000.

BUILDING

A one story building 100 feet by 150 feet, or 15,000 square feet, is required for the manufacture of salicylic acid. The building may be constructed of any local fireproof material.

The estimated cost of this building, including plumbing and wiring, is $4. per square foot or a total of $60,000.

POWER

About fifty horsepower connected load is required. The total estimated annual cost of electric power is approximately $4,000.

WATER

About 2,400,000 gallons of water are needed annually for production purposes and for fire protection and sanitary uses.

The estimated cost of water is $600 per year.

FUEL

About 40,000 gallons of oil are needed annually for production and heating the building.

The cost of oil is estimated at approximately $2,800 per year.

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DEPRECIATION

Description	Estimated Cost	Years Life	Annual Cost Estimated	Annual Cost Actual
Building	$ 60,000	20	$ 3,000	_____
Production tools and equipment	160,000	10	16,000	_____
Other tools and equipment	18,000	10	1,800	_____
Furniture and fixtures	1,000	10	100	_____
TOTAL			$ 20,900	_____

MANUFACTURING OVERHEAD

Item	Annual Cost Estimated	Annual Cost Actual
Depreciation	$ 20,900	_____
Indirect labor	26,000	_____
Power	4,000	_____
Water	600	_____
Fuel	2,800	_____
Supplies	5,000	_____
TOTAL	$ 59,300	_____

MANUFACTURING COSTS

Item	Annual Cost Estimated	Actual
Direct materials	$ 183,100	_____
Direct labor	40,500	_____
Manufacturing overhead	59,300	_____
TOTAL	$ 282,900	_____

FIXED ASSETS

Item	Cost Estimated	Actual
Land	$ 1,000	_____
Building	60,000	_____
Production tools and equipment	160,000	_____
Other tools and equipment	18,000	_____
Furniture and fixtures	1,000	_____
TOTAL	$ 240,000	_____

WORKING CAPITAL

Item		Cost Estimated	Actual
Direct materials	30 days	$ 15,200	_____
Direct labor	30 days	3,400	_____
Manufacturing overhead	30 days	5,000	_____
Reserve for sales collections	30 days	32,500	_____
TOTAL		$ 56,100	_____

CAPITAL REQUIREMENTS

Item	Cost Estimated	Actual
Fixed assets	$ 240,000	_____
Working capital	56,100	_____
TOTAL	$ 296,100	_____

SALES REVENUE

The production capacity of this plant based on three shifts per day, 250 days per year amounts to about 500 tons of salicylic acid per year, or about 1,000,000 pounds annually. The selling price of technical grade salicylic acid produced by this plant would be $0.39 a pound.

On this basis the annual gross sales revenue would be about $390,000.

RECAPITULATION OF COSTS, SALES AND PROFITS

Item	Estimated Cost		Actual Cost
Direct materials	$ 183,100		
Direct labor	40,500		
Manufacturing overhead	59,300		
Total manufacturing cost		$282,900	
Interest on loans	8,000		
Insurance	800		
Legal	500		
Audit	1,000		
Unforeseen expense	3,800		
Total administrative costs		14,100	
Sales commissions		6,000	
Bad debts, freight-out, travel discounts and allowances		4,000	
Profit before taxes		83,000	
Total annual gross sales		$390,000	

BUDGET CONTROL:

A requisition form designed to provide accurate records of procurement and indicate the purpose of procurement with the least amount of time and effort is shown on the following page.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power and water, are usually under contract and are easily checked by reference to monthly bills. For simplification, items (marked with an asterisk below) are omitted from the purchase requisition. Variations in the labor costs are easily reviewed by examination of the payroll vouchers. The simplified type of control thus provided makes certain that the manager can control expenditures promptly.

Following the requisition form, a sample voucher check is shown. Voucher checks should be used for the payment of all expenditures and the appropriate book account number placed on each voucher.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts. If the expenditures exceed the budgeted monthly allowances of any of the accounts, the bookkeeper will furnish the manager with a break-down of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions and the check vouchers. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If at any time during each month it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

BUDGET CONTROL ACCOUNTS:

Account Number		Monthly Expense	Monthly Budget	Annual Budget	Actual
10	Administrative	$_____	$ 858	$ 10,300	$_____
20	Sales	_____	833	10,000	_____
30	Direct Materials	_____	15,258	183,100	_____
40	Supplies	_____	416	5,000	_____
51	Power*	_____	333	4,000	_____
52	Water*	_____	50	600	_____
53	Fuel	_____	233	2,800	_____
60	Unforeseen Expense (Reserve Account)	_____	316	3,800	_____
71	Direct Labor*	_____	3,375	40,500	_____
72	Indirect Labor*	_____	2,166	26,000	_____
80	Depreciation (Reserve Account)	_____	1,741	20,900	_____

PURCHASE REQUISITION	COMPANY NAME	DATE

☐ 10 ADMINISTRATION ☐ 40 SUPPLIES

☐ 20 SALES ☐ 50 UTILITIES

☐ 30 MATERIALS ☐ 60 UNFORESEEN EXPENSE

INDICATE BELOW THE USE OF MATERIALS

☐ DIRECT MATERIALS ☐ MAINTENANCE SERVICES

☐ MAINTENANCE MATERIALS ☐ OPERATING SUPPLIES

	PLEASE ORDER THESE MATERIALS OR SERVICES	DELIVERY WANTED	
QUANTITY	DESCRIPTION	UNIT	TOTAL

QUOTES FROM		REQUISITIONED BY	
QUOTES FROM		APPROVED BY	
QUOTES FROM		ORDER NO.	ORDER DATE

R. W. MITCHELL MANUFACTURING COMPANY

1422 BOSWORTH STREET, S. E.

65-22
514

ANYWHERE, U. S. A. _____ 19____ No. 10000

PAY _____ DOLLARS $ _____

TO THE ORDER OF

R. W. MITCHELL MANUFACTURING COMPANY

TO FIRST NATIONAL BANK
ANYWHERE, U. S. A.

BY SAMPLE CHECK

VICE PRESIDENT

YOUNG & SELDEN CO

ACCOUNT NUMBER

Sample voucher check to be used for the payment of all expenditures in connection with Budget Control.

ENGINEERS:

The services of professional engineers are desirable in the design of this plant, even though the proposed plant is small.

A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers
2029 K Street, Northwest,
Washington 6, D. C.

Manufacturers of industrial equipment employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed project.

The equipment manufacturers also know, and can recommend, professional engineers in private practice, who are willing and able to provide appropriate consulting services.

TRAINING:

Manufacturing an inferior quality of product during the training period could create sales resistance that might be difficult to cope with later. To avoid such possibilities, the quality of the product should be maintained at all times, including the training period.

In some areas skilled operators may be available locally. In other areas all the operators may have to be trained.

If skilled operators are not available, adequate training would be assured by using one or more of the following methods:

A. If the plant is designed and installed by a competent engineering firm, the contract should be negotiated, if possible, on a turn-key basis. On this basis the contractor agrees to operate the plant and produce the quality and quantity of the product stated in the contract for an agreed period of time. Such a contract would assure adequate personnel training, since full quantity and quality could not be produced with an untrained organization.

B. The engineering firm that designs and installs the plant can usually make training arrangements to have key personnel placed, for training purposes, in a foreign industry that produces the same type of product. This would provide training for the key personnel while the plant is being installed.

C. If neither of the above methods is possible, then qualified and experienced individuals should be employed for the key positions, either permanently or temporarily, to perform the key operations and assist in training the organization, even if they must be secured outside the country.

D. The manager should have years of successful experience in this type of business and be fully qualified in all phases of management, including the training of employees.

SAFETY:

There is always danger of accident and injury in any industrial plant. Because of this, the manager should take specific action to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

Practically all machines have safety appliances, and the manager should see that these are in good working condition and that the operators are making full use of them.

In addition to constant watchfulness to make sure that all practicable safety precautions are taken, first aid supplies should be readily available. One complete first aid kit should be maintained near the manager's office, and others at appropriate places throughout the plant. Some of the employees should be trained to provide first aid service.

The use of accident posters in the plant have proved to be of value in reducing accidents. It is recommended that such posters be used, and that some direct special action be taken by the manager, at least once each month, to bring to the attention of all personnel the importance of safety precautions.

A fire brigade should be established and each member trained as to his responsibility in case of fire. Fire drills should be conducted periodically.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.

OTHER CONSIDERATIONS

There are other important subjects, shown below, that should be fully investigated and considered. Information on these subjects is usually available from such sources as banks, government agencies, exporters and importers, wholesalers, retailers, transportation companies and manufacturers.

MATERIALS AND SUPPLIES

1. Are all materials and supplies available locally?
2. Is the local material market competitive?
3. Is satisfactory delivery of local materials assured at reasonable prices?
4. What materials and supplies must be imported?
5. Are they available in world markets at competitive prices?
6. Would prompt delivery of imported materials and supplies be assured so that large inventories would not be required?

MARKET FACTORS

1. Is there already a demand for the product?
   - A. Who are the principal consumers?
   - B. Who are possible new consumers?

2. How is demand for the product now satisfied?
   - A. By local production? If so, what is the volume of annual production?
   - B. What percentage of consumption is filled by local production?
   - C. By imports? If so, what is the volume of annual imports?
   - D. What percentage of consumption is met by imports?
   - E. From what areas are imports derived?

3. What is the estimated annual increase in local consumption over the next five years?
   - A. How were such estimates made?
   - B. By reference to official figures on population growth, family budgets, imports, etc.?
   - C. By consultation with trade or industry, ministries, associations, bankers, commercial houses, wholesalers, retailers, industrial consumers, etc.?

4. If the product is already being manufactured, can the existing and estimated future local market absorb production of the new plant without price-cutting or other dislocations?

5. Would the estimated sales price and quality of the new product make it competitive with an imported equivalent?
   A. After adjusting cost to local conditions, is the estimated sales price of the product so high that tariff protection is necessary to protect it from imports?

EXPORT MARKETS:

1. Could the product compete in export markets on the basis of price, quality and dependability of supply?
2. Can export markets for the product be developed?
3. If so, in what areas and in what annual volume?
4. What procedures would be necessary to develop export markets?
5. What would it cost?

MARKETING PROBLEMS:

1. In calculating costs of the product, has adequate allowance been made for the expense of a sales department, advertising and promotion that might be required?

2. Do consumer prejudices against locally manufactured products exist?
   A. If so, why?
   B. Would they apply to the new product?
   C. If so, how could they be overcome and what would it cost to do so?

3. Do marketing and distribution facilities for the product exist?
   A. If not, can they be set up?
   B. What would it cost to do so?

4. Will the product be sold to:
   A. Wholesalers?
   B. Retailers?
   C. Direct to consumer?
   D. Other industries?
   E. Government?

ECONOMIC FACTORS:

1. How much foreign exchange (and in what currency) is required to import machinery, equipment and supplies:
   - A. How much foreign exchange (and in what currency) is required for annual interest payments and amortization of any loans contracted to import machinery and equipment, or for payment of royalties and technical services?
   - B. How much foreign exchange (and in what currency) is required for annual import of raw materials and supplies?
   - C. What are estimated annual foreign exchange earnings and in what currencies?
   - D. Has careful consideration been given to the possibility of depreciation in the foreign exchange value of the local currency?
   - E. Has careful consideration been given to the possibility of import controls, or restrictions on availabilities of foreign exchange necessary to operate the business?
   - F. What benefits would the new business bring to the economy in the use of local raw materials: in employment and in technology?
   - G. Do dependable facilities exist for transportation, power, fuel, water and sewage?
     - (1) If not, can existing deficiencies be eliminated satisfactorily?
     - (2) What would be the cost to do so?

PERSONNEL:

1. Is there an adequate labor supply near the plant location?
   - A. If not, how can the problem be solved?

2. Can the problem of training competent management and supervisory personnel be solved?
   - A. Also, the training of skilled labor?
   - B. Is technical advice available in the locality?
   - C. If not, where can it be obtained and what will it cost?

LAWS AND REGULATIONS:

1. Do existing labor laws, government regulations, laws and taxes favor establishment of new business?
   - A. If not, can existing obstacles be removed?
   - B. If so, how and when?

FINANCIAL FACTORS:

1. Technical advice on selection of machinery and equipment.
   A. In selecting the machinery and equipment for the new plant, have reputable and competent engineers and technicians been consulted?
   B. Have they been asked for advice on the most suitable types of machinery and equipment for the process and locality?
   C. Have they carefully compared costs of various suppliers?
   D. Credit terms offered purchasers?

FINANCIAL REQUIREMENTS OF THE PROJECT:

1. In estimating the cost of the project, has careful consideration been given to:
   A. The effect on costs of delays in construction schedules?
   B. In delivery and installation of machinery and equipment?
   C. In import of essential raw materials and supplies?

2. In calculating cash flow and working capital requirements, has careful consideration been given to:
   A. Maintaining adequate inventories of raw materials?
   B. Supplies and spare parts?
   C. Seasonal fluctuations in the business?
   D. The time required to liquidate credit sales to customers and bad debts?
   E. The period necessary to get the plant into production?
   F. Cash required to amortize its principle loans?

3. If the economy is in a period of inflation, has full allowance been made for the influence of rising prices and wages on the cost of the project and on working capital requirements?

SHORT TERM BANK CREDITS:

1. Has it been possible to make arrangements with local banks to finance short-time working capital requirements of the business?

FINANCIAL PLAN:

1. Has a definite plan to finance the project been worked out?
   A. Is sufficient capital available locally?
   B. If not, what is the plan to obtain the required capital?

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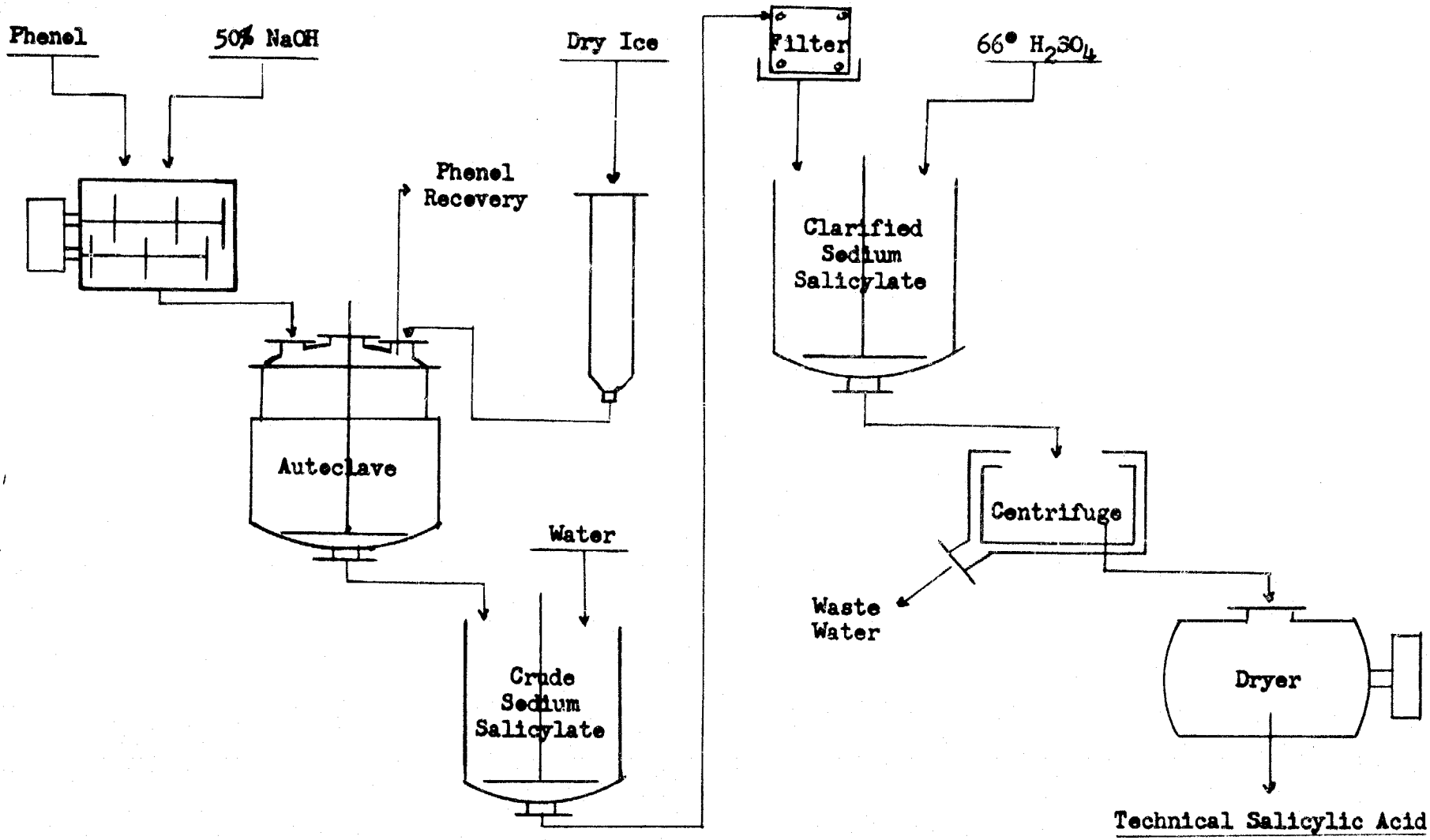
Building requirements including storage.

One story 100' x 150' or about 15,000 square feet.



FLOW SHEET FOR MANUFACTURE OF TECHNICAL SALICYLIC ACID

Since equipment is mainly tanks no pictures are included